DOCUMENT RESUME

ED 442 817 TM 031 237

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TITLE Where Did All the Data Go? Internet Security for Web-Based Assessments.
PUB DATE 2000-04-00
NOTE 32p.; Paper presented at the Annual Meeting of the National Council on Measurement in Education (New Orleans, LA, April 25-27, 2000).
PUB TYPE Opinion Papers (120) -- Speeches/Meeting Papers (150)
EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS *Computer Security; *Data Analysis; Performance Based Assessment; *World Wide Web

ABSTRACT

The purpose of this paper is to enumerate a series of security steps that might be taken by those individuals or organizations that are contemplating Web-based tests and performance assessments. From a security viewpoint, much of what goes on with Web-based transactions is similar to other general computer activity, but the recommendations focus on what can be done to avoid data compromise and loss or to resurrect such information should it be modified. Some very specific advice is offered. An appendix lists Web sites to visit about security. (Contains 12 references.) (SLD)

Running Head: Internet Security

Where Did All the Data Go? Internet Security for Web-based Assessments

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Paper presented at the annual meetings of the National Council on Measurement in Education, New Orleans, LA, April 25-27.

Abstract

The purpose of this paper is to enumerate a series of security steps that might be taken by those individuals or organizations that are contemplating web-based tests and performance assessments. From a security viewpoint, much of what goes on with web-based transactions is similar to other general computer activity, but the recommendations here focus on what can be done to avoid data compromise and loss or to resurrect such information should it be modified.

Introduction

Several testing companies have now released tests for administration over the World Wide Web (the web) or are well into the process of doing so. While computerized testing has been in place for almost a decade, the use of the web as an administration format is relatively new (Shermis, 1997). The advantages of using the web as an administrative format are numerous, including: global reach, standard interface, immediate updating, centralized control, and ease of use. These advantages are often weighed against two significant drawbacks: inconsistent connectivity and a proneness to security risks. The remainder of this paper is devoted to discussing the possible data collection risks for computerized testing with a special emphasis on the web-based format. The former problem can be ameliorated by installing multiple servers, implementing server load-balancing, upgrading connectivity, dedicating lines, or some combination of these steps.

Where to Begin?

> The overwhelming attacks this week against some of the Internet's biggest companies required dozens of powerful ``zombie'' computers collectively aiming a crippling tide of data at target Web sites. Experts believe the hackers earlier had infiltrated and secretly installed

> their attack software on these computers, setting them up as unwitting accomplices in a crime-in-the-making. Were the operators of these computers merely victims of these unprecedented assaults, or were they partly to blame? It's a question with enormous consequences for the Internet, the sprawling worldwide network that has few rules and where security can range from ironclad to nonexistent. As the Internet's importance grows as an engine for America's economy, some experts wonder whether unsafe computers can continue to be tolerated, or whether there is any alternative. (Bridis, 2000)

This snippet, taken from an Associated Press Technology release, summarizes a recent breach in Internet security that paralyzed a number of U.S. commercial firms for a span of two days. The consequences of such an intrusion are potentially expensive in terms of money, labor, and most importantly, consumer confidence.

Because Internet transactions are a relatively new phenomenon, people tend not to trust them as much as they do more familiar paper transactions. For example, my friends often object to me paying for items over the web because of the possibility that my credit card number might be intercepted. These are the same people who, in a restaurant, give a perfect stranger their credit card, follow this individual with their eyes as he disappears into the back of the establishment, and who must unconsciously pray that he only uses the card for

legitimate purposes. In contrast, my web transactions go into a secured area and are encrypted with 128-bit technology. Even if someone could intercept the transmission, it would take a bank of computers and a very long time to extract the card information in order to do anything with it.

There are probably no "bullet-proof" security systems that will protect one against every possible mechanism that would compromise, corrupt, or destroy data collected by via the World Wide Web. Given the fact that a computer could fail at any possible moment, there will always be some risk involved.

Before any trouble occurs one might wish to engage in a risk analysis. The process involves examining the computer system for information that needs to be protected, and whether that information is subject to a possible security threat. This will help to determine where trouble is most likely to occur by pinpointing weak spots in the system. By performing this simple procedure, valuable time can be saved when attempting to restore lost information or functions. There are three relatively simple steps involved in performing this analysis.

The first is determining precisely which components are security risks. All applications and data should be

inventoried to establish a record of the present components. If the system is very large, an inventory management system can be used to keep track of the system components. Software such as the Zero Administration Client (ZAC), by McAfee, is a useful alternative for the management of a large system.

The second step is to examine the concrete ways in which threats could occur. Examine each component individually to identify specific problem possibilities. Examples of these possibilities include software failure, power loss, hardware failures, tampering and hacking, etc.

The final step is to develop recommendations for solutions to each possible threat to every component. By systematically generating solutions to each problem examined in the second step, one can generate a checklist of procedures that can be easily accessed and followed in times of emergency (Benson, 1998b).

A number of security actions should be taken to insure the safety and well being of the organization's network. The situations and areas that should be accounted for are: recovering from disasters, the development of security policies, user-end security, security for menu systems and control programs, virus protection, physical security and possible threats from the Internet. While most of the

headlines regarding data loss or compromise have focused on external threats, the probability runs about 10:1 that if you have a problem, it is likely to stem from an internal concern. Far more data is lost because someone didn't back up a file than from a malicious hacker snooping for open ports in your network.

When a situation occurs that results in the loss of information or applications, recovery can be made easier if a contingency plan has been developed beforehand. By deciding what actions to take prior to the emergency, the process of recovery will be easier and less stressful. The back up plan should explicitly outline which actions are to be performed, the situation that should precede these actions and the actual person responsible for carrying out the actions. The best choice for this person would be the system administrator or the employee with the most knowledge of the system. If this is not possible, then someone should be specifically trained for these particular situations. There are three steps to developing an effective back up plan. First, all critical data should be backed up and stored in an off-site location in case of an equipment or virus-related emergency. Secondly, an emergency power supply system and surge suppressors should be installed. This will protect against damage from

blackouts or power irregularities. Lastly, startup disks should be made for each computer, so that they can be rebooted cleanly after damage from a virus has occurred (Benson, 1998b).

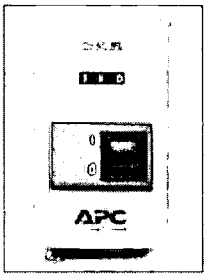


Figure 1. An example from a battery backup system/universal power supply (American Power Company).

Developing Security Policies

Next, the organization should work toward developing effective security policies. Developing a policy differs from company standards and procedures. Standards and procedures describe exactly how the policy is to be carried out. A good policy will simply be an overall approach to insuring the security of the system, specifying which parts of that system are to be secured. The policy is made up of four parts: the purpose, the scope, general policy statements and policy standards (Benson, 1998b). The purpose describes what the policy is intended to accomplish. The scope tells who and what will be subject to obey the policy. General policy statements are the

rules by which the policy is put into place. These rules should indicate the people and positions responsible for certain tasks, define the use and misuse of the computer system, who will receive access to the system, which parts of the system need to be protected, and the consequences of violating the policy. Lastly, policy standards should be stated, in which the tasks necessary to support the policy statements are listed.

Physical Security

It is only with a modest sense of irony we point out that perhaps the easiest way to lose computerized test data is for someone to walk into a testing facility and physically remove a computer or hard disk. It is not impossible to prevent and there are several things you can do to discourage theft of this nature. First make sure the testing facility can be locked. At our facility, the center key is not part of the organization's "master" system, and the center staff are the only individuals with keys to the room where computers are kept. We also have a separate key-coded alarm system (code is changed once a month). When the room is opened up in the morning the alarm has to be deactivated. When the alarm is off, the room is continuously staffed by at least one individual.

Similar security is in place where our web-based servers are kept.

Each of the computers is secured by a locked cable. More challenging systems allow you to bolt your computer to a metal plate that is glued to a desk; however, sometimes the more intimidating physical security systems can impose constraints on how the CPU or monitor can be positioned. Computers may also be "fortified" with devices that block access to floppy drives, removable hard drives, or CD-ROMs. Many computers also provide for the option of requiring a key insertion and turn before the CPU can be booted.

The room that is used for testing should, of course, have dedicated electrical circuits and plenty of HVAC to handle the heat that computers generate. In examining the physical layout of your space, you'll want to ensure that ceiling access is also blocked as many buildings use false ceilings. Clever thieves can gain access to a room by crawling through the false ceiling space and dropping down into the testing facility.

Front-End Security

If a PC is to be accessed by outside or multiple users, "front-end" security should be established. This is accomplished by securing menu systems that provide access to the control programs. These programs in turn, provide

entrée to files and applications that must be protected. By restricting access to these programs, the organization reduces the risk of damage to important files and applications due to the actions of users not familiar with network.

Secure Menu Systems

Along the same lines as installing front-end security, securing menu systems involves disabling some "user-friendly" options that are designed to provide easy access to all parts of the system. All Microsoft Windows operating systems contain the program Everybody's Menu Builder 2.0. This program assists in the creation of a user-friendly menu system with the benefit of extra security. Included in its' features is the ability to disable the CTRL+ALT+DEL (rebooting) function, which automatically shuts down the machine, and disables the mouse's right click contextual menus. Eliminating the PrtScr (print screen) button on some computer keyboards would fall under the same consideration.

Password Protection

One of the most under-utilized and abused security features implemented in most computers has to do with password protection. Many computers have the option of requiring a password before allowing a computer to complete

it boot-up process; nevertheless this feature is often disabled because it is considered an inconvenience. Even when passwords are required, many users will resort to easily guessable defaults (e.g., "guest", "admin", "user1") rather than implementing a secure alternative. Passwords should be at least 8 characters long, should consist of letter-number combinations, and should not among those that are commonly used (e.g., "studmuffin", "princess", "genius"). It should be noted that even good password systems can be compromised if the password information is not properly encrypted the program that uses it. We discuss encryption later on in this paper. A common way to force users to select safer passwords is for the system administrator to set minimum password limits for all users. This means that every user password must have a minimum number of characters, and even a minimum number affecting the type of characters used. The typical number of characters required usually ranges between six and eight. Also required in many systems is the inclusion of at least one non-alphabet character, for example, numbers or punctuation marks. This makes the process of password hacking much more difficult. Hackers will often use dictionary software to scan for passwords in a variety of languages. By adding non-alphabet characters into the

password, the dictionary scan can be thwarted. There are a few emerging programs on the net (e.g., AntiCrack) that can assess a password for potential vulnerabilities to cracking.

Connecting to the Internet

The whole business of preventing external threats to your network ends up consisting of a number of incremental steps designed to thwart the attempts of others in a game of Internet "cat and mouse". One of the easiest ways to prevent external intrusions is by disconnecting from the Internet and simply running a local area network (Intranet). Combined with proctoring of the machines, a secure menu system, and attention to safety (backing up, emergency power supply, and anti-virus software), your system will be relatively secure.

However, if you must be connected to the Internet to perform your web-based testing, there are some steps you can take to help secure your site. First, perform a computer security check-up. It is possible to have your system analyzed to determine the weaknesses for which it is vulnerable. For example, Shields UP! (https://grc.com/x/ne.dll?bh0bkyd2) can perform a basic analysis for Windows-based machines. After connecting to your network, this web site will return a full report on

technical aspects of your communications setup such as the number of open ports and how stealthy your system is to outside intruders. Fig. 2 illustrates a screen shot of a component of the Shields Up! web site.

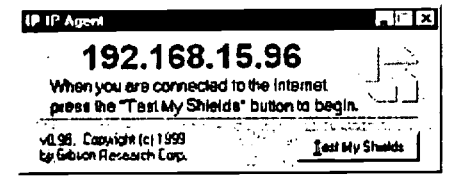


Figure 2. A Component of the Shields Up! Internet Connection Security setup.

Firewalls

In addition to examining your Internet vulnerabilities, you can also install a firewall. In its original incarnation, firewalls were computers that protected the local networks and dial-in lines by controlling information that was let in or out (Benson, 1998a). Today, one can obtain a "personal firewall" which runs on an individual client machine and offers a similar level of protection. For example, Zone Alarm 2.0 is freeware that will install a "personal firewall" on each machine in the network. Alternatively, a number of vendors offer network firewalls that operate off a dedicated machine.

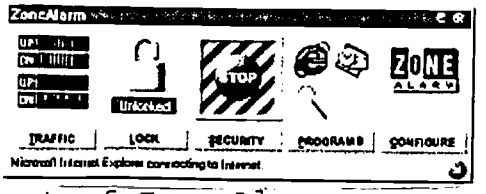


Figure 3. A Component of Zone Alarm, a personal firewall.

In contrast to a firewall, a proxy server masks the network to outsiders. For example, all Internet protocol (IP) requests for information may go through the proxy server, so those on the outside are unable to differentiate one machine on the network from the rest.

Viruses & Trojan Horses

If a user has legitimate business on your server, the most common compromise of data is most likely accomplished with good intentions—the client introduces a computer virus. A virus is actually a program that can destroy, delete or "lock up" information and applications on a system. If data is not damaged, the virus can still be troublesome in that it takes up valuable disk space and memory. Viruses are often attached to some sort of host program, where the execution of the program causes the execution of the virus. These programs commonly take the form of Trojan Horse viruses. The Trojan Horse virus performs its' action covertly and is delivered via a host program or "dropper" (McClure, 1999).

These viruses typically enter the computer system in one of three ways: by disk, downloads, or attachments. Floppy disks used on other systems can be used to unwittingly "transmit" the virus when opened on another system (Campbell, 2000). Downloading information from any online service can introduce virus programs. Lastly, email attachments carrying a virus, when opened, carry the potential to damage systems. Often reports of these are exaggerated and many of them are hoaxes, but the possibility does exist. There are several websites that list the names of popular virus warnings that are typically sent via e-mail. These websites differentiate between warnings that are hoaxes and those that are actual threats (Thornloe, 2000).

Anti-virus software is the most common protection from this type of threat. When looking to choose an effective anti-virus program, there are some factors that should be taken into account in order to insure the best fit with the intended system. First, the type of system can make a difference. Further, is the system networked and if so, should the entire network be protected? Also, check the types of virus detection and prevention offered by the software. There are several options that a good virus protection program should offer. The user should be able

to receive virus protection updates from the company. This updated information should help protect systems from newly developed viruses. Two types of scanning practices are used in virus detection. Signature-based scanning should be used to detect the virus before it is brought into the system and before the opportunity arises for it to activate. One way this is accomplished is through heuristics-based scanning, which is a program that checks for codes commonly used to create viruses. Another method is using memory-resident monitoring to check the memory for an existing virus. The software should also regularly check the integrity of program files to determine whether changes have occurred. Companies such as McAfee or Symantec provide various types of anti-virus software depending on the needs of the system. There are also free anti-virus software or "freeware" that can be downloaded from the Internet.

If a virus has infected a computer in the network, there are a series of steps that should be followed immediately. First, close all applications and shut the computer off. Then, insert a write-protected emergency startup disk and turn the computer on. Next, follow the instructions on the anti-virus software to scan the directory for infected files. The software will then

remove the virus from each infected file. After all files have been scanned, shut down the computer and reboot. Afterwards, all floppy disks should be scanned so that a re-infection does not occur. If the virus is still infecting any files, follow steps in the software to delete infected files.

Encryption

One frequently employed security measure, used when sensitive information is transmitted from one source to another, is encryption. Encryption is the transformation of data into a form that is nearly impossible to read without the use of a key (Schneier, 1996). Information is first transferred into an encrypted, or unreadable, form and sent to a certain destination. Once it arrives, an authorized party uses a key to decrypt, or decode, the information. In a public and private key system, the public key is shared among authorized users and is used for encryption only. Once the information is received, it can only be decoded by the recipient's own private key. The private key is accessible only by individual recipients. Secret key systems are also employed, in which both sender and recipient encode and decode information with the same key. However, it can be difficult for both parties to agree on a particular key without the fear of someone else

discovering this information. All of these keys have life cycles that eventually cause keys to expire, which insure that new keys are constantly being developed and used (Schneier, 1996). This is very important considering the common uses for encryption. Sensitive data can be transmitted and shared with little fear of being lost or stolen, if the encryption software is effective and current and if the program has been implemented properly. When data is successfully intercepted and decrypted, it is rarely because the actual code has been broken. Often it is easier for intruders to look for holes in the implementation. Lapses in security are much easier to exploit than the complex methods employed by encryption programs.

Nitty Gritty

As we alluded early on in this paper, most of what can go wrong with Internet data collection is common to many other types of computer transactions—power loss, virus infection and the like. There are processes that go on specific to the Internet, and what follows is a brief description of the rare occurrence of outside intruders trying to gain access to a web-based data collection server.

Footprinting

The first step an outside intruder will use to gain access to a site is called "footprinting". Footprinting is the creation of a profile of an organizations' system using a fairly systematic method of examination. Hackers frequently use a variety of techniques to compile information regarding organization sources such as the Internet, extranet, intranet and remote access. The first phase of footprinting involves determining the limits of what is to be examined. For example, footprinting an entire organization is very different from footprinting only specific parts of the organization. Next, the hacker will perform an open source search, usually by checking the organization's official web page. Several key pieces of information can be determined simply from examining the site. Hackers can also gain important information by employing various query types. The four main types that are typically accessed are organizational, domain, network and point of contact (POC) queries. Potential intruders can also view the domain name server (DNS), a database containing IP addresses and their matching host names (McClure, 1999). Firewalls are typically used to prevent extensive footprinting by unauthorized users. It is also

recommended that intrusion detection be used in addition, to log any attempts to footprint the organization's system.

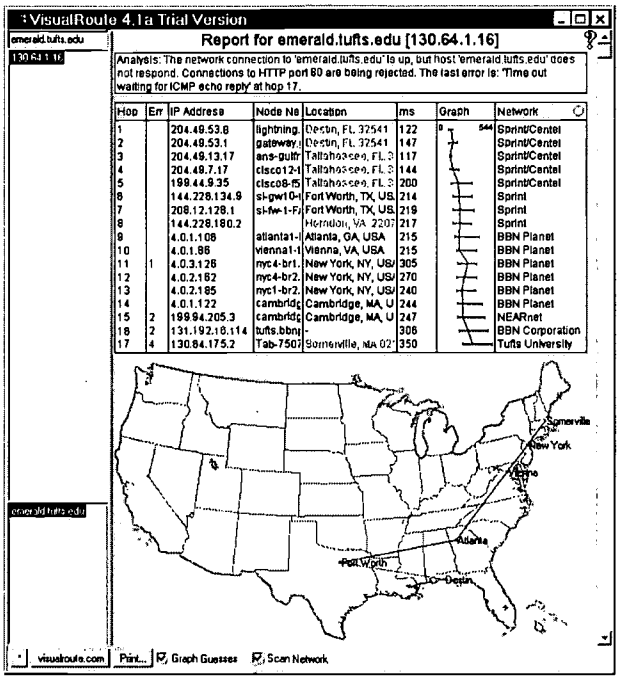


Figure 4. VisualRoute is a program which allows you to query the connections and routing for a particular domain. It will also permit you to collect network and domain *whois* information (Source: http://www.visualroute.com/press/emerald1.gif).

Port Scanning and Pinging

Once the weaknesses of an organization have been discovered, the intruder will attempt to determine if those weaknesses are exploitable. Two common methods of this type of scan are Ping sweeps and Port scanning. Ping sweeps consist of sending echo packets to those IP addresses that have been detected during the footprinting

process. The pings will report whether the IP address is alive and available for attack. Due to the fact that ping attempts often precede an attack, it is crucial to detect these attempts as soon as they occur. Ping detection programs such as Network Flight Recorder (NFR) can detect the origin of the ping sweep and help determine when an attack may occur. Once these vulnerable systems have been identified, the process of port scanning can take place. This is when the open (TCP and UDP) ports of a system are scanned to determine what type of operating system is in place and what kind of applications are being used. Once open ports are infiltrated, intruders can mask their origin, take up disk space, attempt to bypass firewalls, and further compromise the system (McClure, 1999). The more ports that are in "listening" mode, or in use, the more vulnerable the system is to infiltration. Like detection of ping sweeps, detection of port scanning attempts is important to determine from where and when an attack may occur.

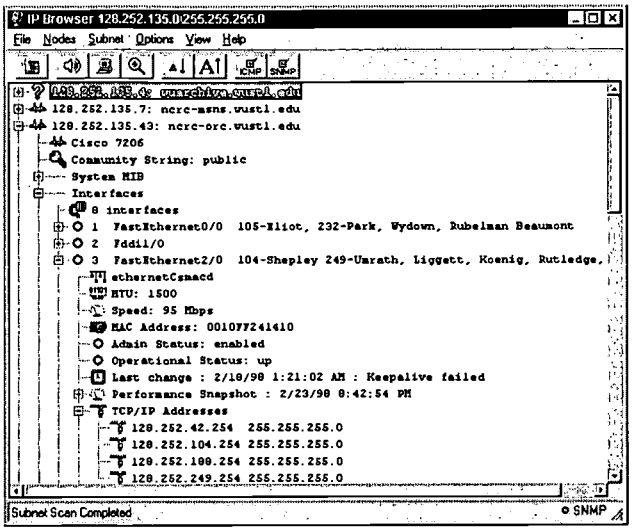


Figure 5.IP Nework Browswer (Source: http://solarwinds.net/IPNetworkBrowser/)

Figure 5 is a screen-shot of a program that can scan an IP subnet and show what devices are responding on that subnet. Each of the responding devices is then queried via SNMP. More details about each device can then be displayed also.

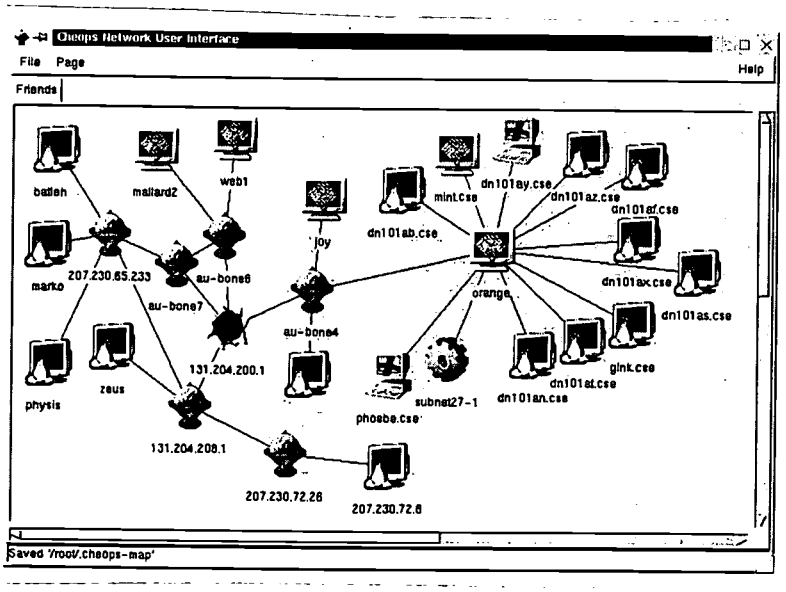


Figure 6. Cheops can help a system administer or external threat locate network resources (Source: http://www.marko.net/cheops/).

Keystroke Logging

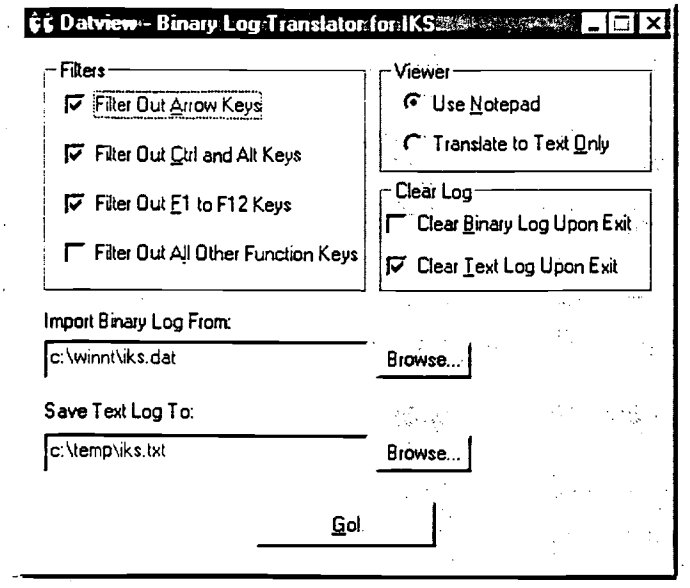
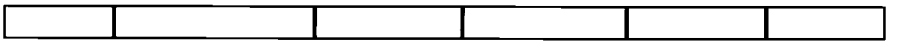


Figure 7. Invisible KeyLogger Stealth for Windows NT (Source: http://www.amecisco.com/iksnt.htm).

Invisible KeyLogger Stealth is a keystroke recorder that can capture even NT's "trusted path" -- alt-ctrl-del logon. It's a security auditing tool that has gained favorable reviews from some of the most prominent security auditors in the business.

Software Vulnerabilities

Microsoft IE external.NavigateAndFind() Cross-Frame Vulnerability



Using the window.external.NavigateAndFind() function it is possible for a remote server to execute arbitrary javascript code on an IE4, 5 or 5.1 client machine in the local security context.

This function is used to load a web document and search it for specific strings, displaying the results in a secondary frame. However, the function will accept URLs of the form "javascript:", and should such a URL to passed to the function, the javascript is executed in the security context of the content of the secondary frame, and has access to that frame's current content.

This weakness could be used to retrieve pwl files, the local SAM database, cookies or any other locally stored information that the user has read access to. The attack could be made via the web, or in an HTML email or newsgroup posting.

Figure 8. Still not sure whether you are open to attack? (Source: http://www.securityfocus.com/bid/887).

Figure 8 illustrates a posting from a network security company that lists some weaknesses associated with some of the more popular network browsers.

Exploiting Your System

Once an intruder has identified the weak points in the system, these spots will likely be used as access points to the network. These points can be identified by successful footprinting techniques or by successful port scans. These open ports then provide an open door for the intruder.

After the network has been accessed, the goal of the intruder is to gain access to the machine of the system administrator. This will give the intruder full access to the entire network. As mentioned before, the importance of passwords is greatly underestimated. If an administrator or employee leaves passwords on the default setting, the system can be accessed relatively easily. Intruders who are simply familiar with the organization's software can crack these generic passwords. This type of mistake is attributable to either ignorance of the importance of secure passwords (usually on the part of the average employee)or laziness (usually on the part of the administrator) and can be corrected simply by supplying all members of an organization with information regarding their accounts and passwords. Even if strong passwords are used, the system is still in potential danger. The intruder may install a keystroke logger on at a remote location within the system. After waiting for a short period of time, the network ids and passwords of various individuals can be viewed by the intruder. The information gained allows the hacker to access more machines in the system via hidden Trojan programs until he finds an entry by the system administrator. After the system administrator's password

is discovered, the intruder gains access to the entire system.

What Now?

Let's say that you're site has been compromised, but you've finally figured out the problem, and you've hired security experts to squelch further incursions. Are you totally out of luck? Depending on the length and extent of the data compromise or loss, you may still be able to reconstruct some of your data, IF you've backed up on a regular basis. Depending on how malicious the activity of your intruders, you may still be able to retrieve data from your original server or hard disks. For example, some programs that "erase" data only eliminate the file name from the file allocation table; the actual data may still reside on the hard disk until overwritten by some other file. File management programs like Norton Utilities may be able to unerase files that have been "eliminated".

The moral of our paper is that one can never be too careful when it comes to evaluating both the motives of people and the capabilities of technology—most of us tend to underestimate the good intentions of those around us and overestimate the wizardry of machines. By taking a systematic approach to evaluating the security of your test

site, you can avoid the embarrassing prospect of asking, "Where did all the data go?"

Appendix A: Places to Visit About Security

Hacking Exposed www.hackingexposed.com

RSA Security Homepage www.rsa.com

Computer Security Institute www.gocsi.com

Computer and Network Security Index

www.vtcif.telstra.com.au/info/security.html

Virus Bulletin www.virusbtn.com

Computer Security Information www.alw.nih.gov/Security/

UN on Computer-related Crime

www.ifs.univie.ac.at/~pr2gq1/rev4344.html

COAST Security Archive Group

www.cerias.purdue.edu/coast/archive/

Network Security Library secinf.net/

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Corporate Source: IUPUI Testing Center	Publication Date: April 25, 2000

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Running Head: Internet Security

Where Did All the Data Go? Internet Security for Web-based Assessments

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Paper presented at the annual meetings of the National Council on Measurement in Education, New Orleans, LA, April 25-27.